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Facial Biometric-Based ATM Transaction System

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Abstract
In recent years, enhancing the security and convenience of banking transactions has become a primary focus in financial technology. This paper presents the design and development of a Facial Biometric-Based ATM Transaction System aimed at reducing dependency on physical ATM cards and enhancing user authentication. The proposed system initiates the transaction by requesting the user to enter their mobile number, followed by bank selection in case the number is linked to multiple accounts. Once the bank is selected, the user is prompted to enter a 4-digit PIN. Upon successful authentication, the system proceeds to facial recognition for identity verification. Only after a positive match, the user is granted access to the main ATM menu, where standard banking operations can be performed. This multi-layered approach—combining mobile number, PIN, and facial biometric verification—significantly reduces the risks associated with card theft, skimming, and unauthorized access. The system is built using computer vision technologies integrated with secure backend validation, ensuring a balance between usability and security. The solution aims to provide a robust, cardless ATM experience, aligning with modern digital banking trends.

Keywords: *Facial recognition, ATM, PIN verification, Bio metric authentication, Secure transaction.*

1. Introduction

In the digital era, banking systems are rapidly evolving to ensure both security and user convenience. Traditional ATM transactions rely heavily on physical debit or credit cards and PIN numbers, which can be lost, stolen, or mis- used. This raises concerns about unauthorized access, identity theft, and fraud, necessitating more secure and efficient alternatives. The proposed Facial Biometric-Based ATM Transaction System introduces a cardless and contactless method for authenticating users at ATMs. At the first step, the system gives the user a choice to enter either their mobile num- ber or Aadhaar number which is registered to any bank account. Immediately after this entry, the system initiates facial recognition to verify the identity of the user before allowing any further access. In cases where the mobile or Aadhaar number is linked to multiple banks, the user is prompted to select their bank. Once the user is selected bank which is registered to that mobile number, the user is should enter a 4-digit PIN for their bank account for secondary authentication. The use of facial recognition not only enhances security but also simplifies the user experience by eliminating the need for physical cards. The system is especially useful for individuals who have lost their physical ATM cards or prefer a convenient, cardless banking experience driven by modern technology. This project aims to demonstrate the feasibility of implementing biometric security in real-time ATM transactions and to explore how such technology can be integrated with existing banking infrastructure for increased safety and efficiency. As banking and financial systems continue to advance, the demand for secure, efficient, and user-friendly authentication methods has grown significantly. Traditional ATM systems rely heavily on physical cards and PIN-based authentication, which are increasingly vulnerable to security breaches such as card cloning, PIN theft, and unauthorized access. To counter these challenges and enhance transaction security, the integration of biometric technologies—particularly facial recognition—has gained significant attention. Facial recognition provides a fast, touch-free, and secure

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way to verify a user's identity, minimizing the need for physical cards. The proposed system leverages facial recognition as a core authentication mechanism in ATM transactions, complemented by Aadhaar or mobile number input and a secure 4-digit PIN entry. The use of multiple authentication steps enhances the system's reliability and aligns with national efforts to advance Aadhaar- enabled digital infrastructure under the Digital India initiative. The system provides flexibility for users to begin authentication by either Aadhaar number or mobile number. Once verified, facial recognition ensures that the user is physically present and authorized to proceed. This is particularly useful for elderly individuals, visually impaired users, and those who may struggle with remembering PINs or handling cards This project demonstrates how advanced biometrics, combined with secure PIN verification and Aadhaar-based identity, can transform traditional ATMs into intelligent, fraud-resistant, and user-friendly systems. When a user's mobile number is associated with multiple bank accounts, the system prompts them to choose the desired bank, im- proving convenience in managing multiple accounts. [1-3]

2. Methodology

The Facial Biometric-Based ATM Transaction System aims to strengthen ATM transaction security by eliminating the need for conventional card-based authentication. Instead, it employs a layered verification approach that integrates user credentials, facial recognition, and PIN entry to ensure secure and reliable access.

2.1 System Architecture

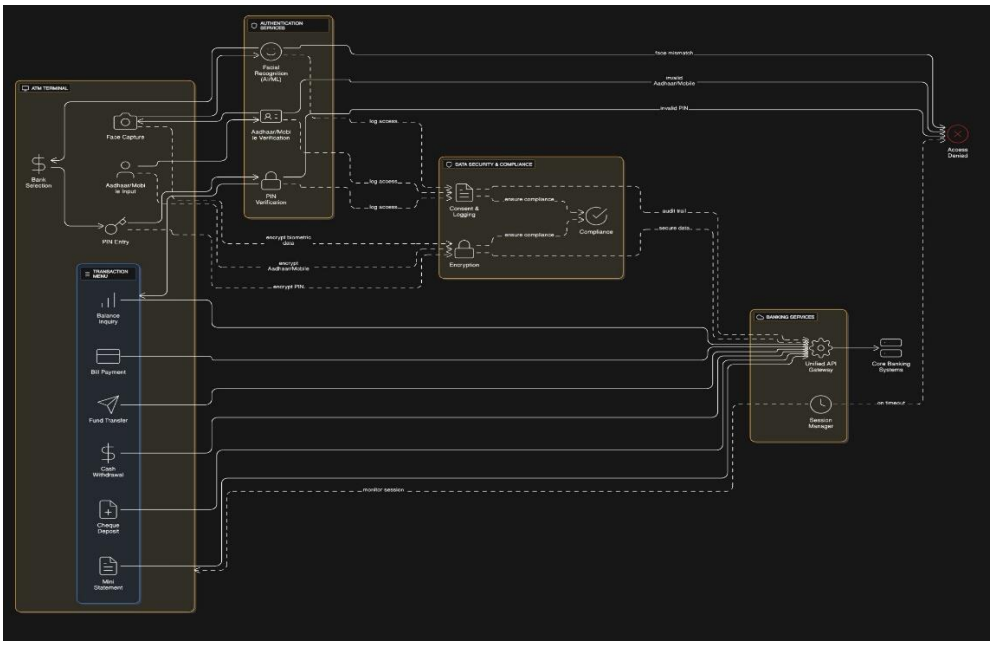

Figure 1 System Architecture of the Facial Biometric- Based ATM Transaction System

User Identity Input Figure 1 shows the system work- flow initially starts by prompting the user to choose be- tween entering their mobile number or Aadhaar number which is must be registered with any bank account. This flexibility ensures that users can authenticate using the method they are most comfortable with. Once the user enters the identification number, the system queries the backend database to check for validity and retrieve asso- ciated account details. Facial Authentication Immediately after the mobile or Aadhaar number is entered, that will check with bank database and aadhaar data to fetch user face then system activates the facial recognition module using a webcam or camera interface. This module captures the user's live facial image and compares it against the stored

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biomet- ric data in the database using face recognition algorithms (such as Haar Cascade or LBPH). This step ensures that the user physically present is the actual account holder. Bank Selection (If Applicable) If the entered mobile or Aadhaar number is linked to multiple bank accounts, the system displays a bank selection menu. Then the user should select the appropriate bank account to proceed with the transaction. PIN Verification After the user successfully completes facial authentication and selects their bank, they are prompted to enter a secure 4-digit PIN. Access to Main ATM Menu Once the mobile/Aadhaar input, face recognition, and PIN verification steps are suc- cessfully completed, the system grants access to the main ATM menu. At this stage, users are granted access to typical ATM functionalities, such as checking their bal- ance, withdrawing funds, initiating money transfers, and reviewing recent account activity. Backend Integration The system connects to a secure backend that maintains user information, facial recogni- tion data, and PINs, all stored in an encrypted format to ensure data protection. All communication between the front end and the backend is protected using secure protocols to prevent data breaches or interception.

2.1.1 Technology Stack the Implementation Is Carried Out Using

- OpenCV for real-time facial recognition MySQL for secure data storage HTML/CSS/JavaScript for user interface design
- This structured approach ensures both ease of use for the customer and robust security for banking institutions.

2.1.2 Face Recognition Module Facial Recognition Is Implemented Using Opencv and Face Recognition Popular Python Libraries. The Process Is Divided into Three Phases

- **Face Dataset Collection:** The user's face is captured dur- ing initial registration. Multiple facial images are stored to improve recognition accuracy. [4-6]
- **Training the Recognizer:** The collected images are used to train the recognition model using the LBPH algorithm, which is robust against lighting variations and minor fa- cial changes.
- **Live Recognition:** During ATM usage, the webcam cap- tures a real-time image and compares it against the stored encoding using confidence scores.
- A match within an acceptable confidence range authenti- cates the user successfully.

2.1.3 Technology Stack the Project Is Developed Using a Combination of Technologies Suited for Real-Time Face Recognition and Secure Data Handling

- **Python:** Core programming language for backend logic and facial recognition modules.
- **OpenCV:** Open-source computer vision library used for face detection and recognition. [7-10]
- **Flask:** Lightweight web framework used to build API endpoints and manage backend routes.
- **MySQL:** Relational database for storing user credentials, facial data encodings, and bank records. [11]
- **HTML/CSS/JavaScript:** Used to design the user interface for mobile/Aadhaar input, PIN screen, and result display.

2.1.4 Database Structure the Database Contains the Following Main Tables

- **User Table:** Stores mobile number, Aadhaar number, name, and bank linkage.
- **Face Data Table:** Stores user ID and corresponding face encodings (in numerical vector format).
- **Bank Info Table:** Manages multiple accounts linked with a single user ID.
- **PIN Table:** Stores 4-digit PINs in hashed format to en- hance security.
- Data is encrypted and accessed via secure endpoints to prevent unauthorized breaches.

3. Results and Discussion

The proposed Facial Biometric-Based ATM Transaction System was implemented using a combination of face recognition, Aadhaar/mobile

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number verification, and a secure PIN-based transaction interface. The system was tested through a series of practical scenarios to evaluate its effectiveness, reliability, and user interaction flow.

3.1 System Output Screens the Implementation Yielded the Following Major Outputs

User Authentication Interface: The system prompts the user to enter either their Aadhaar number or mobile number. Upon successful input, the facial recognition camera is activated. This step adds a critical biometric layer to verify identity and prevent impersonation. Figure 2 shows Initial Page

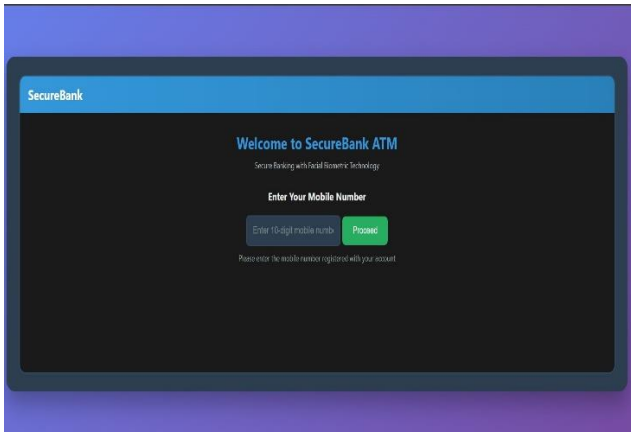

Figure 2 Initial Page

Figure 2 shows Face Recognition Result The face recognition module processes the real-time image input, per- forms feature extraction, and compares it with the stored database. Screenshots show successful authentication when the face matches with stored records. In the event of a mismatch, access is denied, protecting against unauthorized usage. Figure 3 shows Bank Selection Interface For users with multiple bank accounts linked to the same Aadhaar or mo- bile number, a selection menu appears. This feature en- hances flexibility and allows users to transact from their preferred account. PIN Verification and Transaction Menu: After selecting the bank, the user is prompted to enter a secure 4-digit PIN. Upon validation, a menu with multiple ATM services (such as balance inquiry, cash withdrawal, fund transfer, etc.) is displayed.

Figure 3 User Bank Input

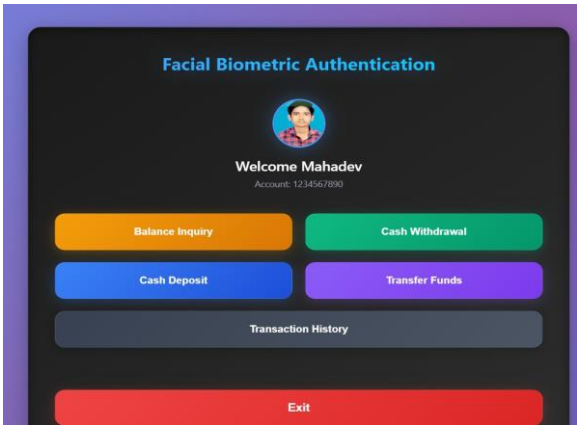

Figure 4 ATM Transactions

Figure 4 shows The ATM Transactions is the final inter- face presented to the user after successfully completing all authentication steps, including mobile or Aadhaar num- ber input, facial biometric verification, and secure 4-digit PIN entry. This menu provides access to core banking functionalities such as balance inquiry, cash withdrawal, fund transfers, mini statement viewing, and PIN change. Each option is designed to be intuitive and secure, allow- ing users to navigate and complete transactions efficiently. The system ensures that only authenticated users can access this menu, thereby reducing the risk of fraud. Additionally, built-in safeguards monitor user activity and terminate the session upon inactivity or suspicious behavior. The interface is optimized for ease of use, making it suitable for deployment across urban and rural ATM locations. Functional Accuracy The face recognition module demonstrated high accuracy under proper lighting condi- tions, with minimal false negatives. Users were authenti- cated within 2–3 seconds. The

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PIN entry added an additional layer of transaction security even after biometric verification. Discussion The system effectively reduces dependency on physical ATM cards and enhances ATM security through multi-layered authentication. The integration of facial biometrics, Aadhaar/mobile verification, and PIN ensures that access to banking services is only granted to verified individuals. The interface is user-friendly and can be adapted for use in rural and urban areas alike.

- However, there are areas where improvement can be considered:
- Environmental factors like poor lighting can reduce facial recognition accuracy.
- Future versions may include fallback methods like finger-print or iris recognition.

Conclusion

This project presents a secure and innovative ATM transaction system based on facial biometric authentication. By eliminating the need for physical ATM cards, the proposed system minimizes the risk of card theft, skimming, and PIN leakage. The integration of Aadhaar or mobile number verification followed by facial recognition and a 4-digit PIN ensures a multi-layered security mechanism that is both efficient and user-friendly. The system successfully authenticates users based on their biometric data, enabling only authorized individuals to access ATM services. The inclusion of a bank selection interface for users with multiple linked accounts further enhances usability and flexibility. The experimental results demonstrate that the system performs reliably under standard operating conditions, with quick and accurate facial recognition responses. The Facial Biometric-Based ATM Transaction System developed in this project offers a modern and secure alternative to traditional ATM card-based authentication. By replacing physical cards with facial recognition and Aadhaar/mobile number identification, the system addresses critical security vulnerabilities such as card skimming, PIN theft, and unauthorized access. The multi-level authentication process—comprising Aadhaar/mobile number entry, facial biometric verification, and a 4-digit PIN—ensures both usability and robust security. The implementation has shown promising results across key ATM functions such as cash withdrawal, balance inquiry, and fund transfers. The graphical outputs from the system indicate accurate detection and matching of user faces, even in real-time scenarios. This reflects the strength of the facial recognition module and its integration with the user database. The ability to handle users with multiple linked bank accounts also adds practical value, ensuring the system can scale to real-world use cases in the Indian banking ecosystem. Additionally, the system has been designed with privacy and data protection in mind. By ensuring encrypted storage of sensitive data such as Aadhaar numbers, facial biometrics, and PINs, the solution remains compliant with modern cybersecurity standards and government regulations. Proper consent protocols and secure backend infrastructure are critical to maintaining trust and system integrity. In conclusion, the proposed system is not only technically feasible but also socially relevant. It aligns with the ongoing push towards digital banking, contactless authentication, and the broader vision of a cashless, cardless economy. With further enhancements—such as support for low-light facial recognition, liveness detection to prevent spoofing, and integration with cloud-based banking APIs—this project can evolve into a scalable and impactful banking solution. Future work may also include support for voice-based interaction, multi-language interfaces, and accessibility features to ensure inclusivity for all users. In conclusion, the Facial Biometric-Based ATM Transaction System holds significant potential for improving banking security and user convenience. With proper implementation, compliance with data privacy regulations, and further refinements—such as improving recognition in varying lighting conditions—this system can be scaled for real-world banking applications across India and beyond.

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